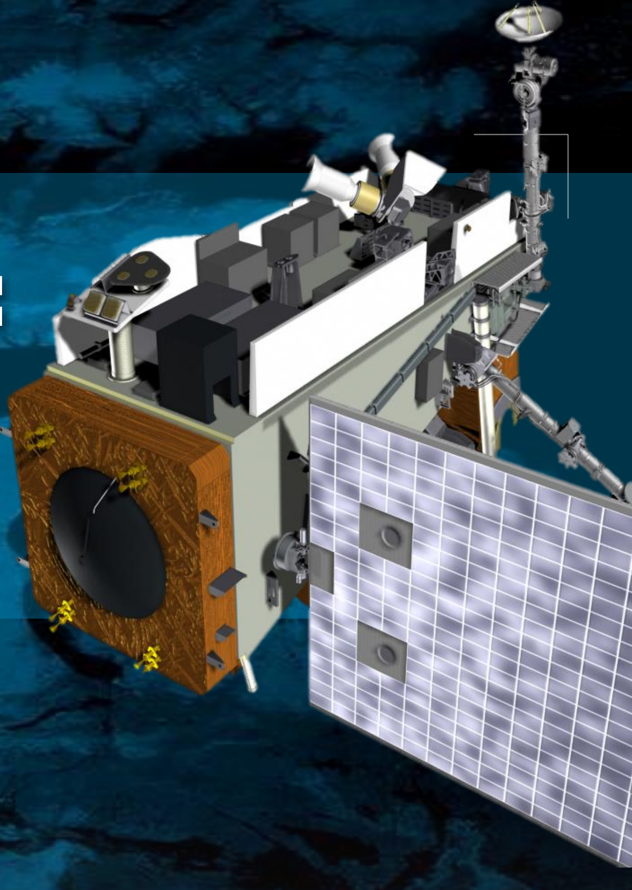
The Low Earth Orbit Constellation: JPSS Mission and Future Plans

Building on Past Satellite Successes to Ensure a Bright Future



Greg Mandt

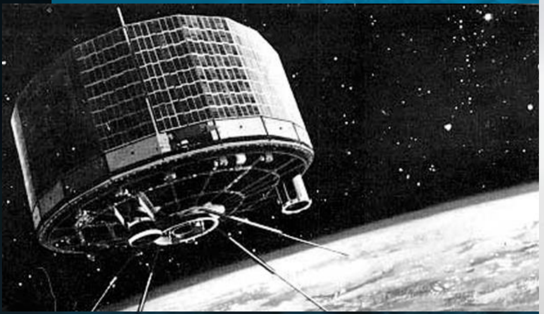
Program Director, Joint Polar Satellite System

GLOBAL **DATA.**
LOCAL **WEATHER.**

Evolving LEO Satellite Technology to Improve Forecast Accuracy

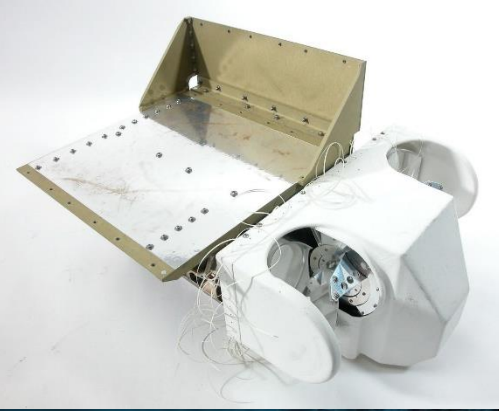
1960

- TIROS-1 launch in April 1960. 48˚ inclination
- Nimbus-1 launch in Aug. 1964. First infrared sensor
- TIROS-9 launch in 1965. “Cartwheel configuration.” First polar orbit



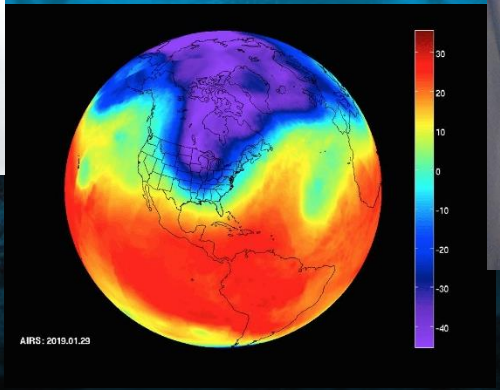
1980

- TIROS-N launch in October 1978. First AVHRR
- First microwave sounder—increase in forecast accuracy due to ability to see through clouds



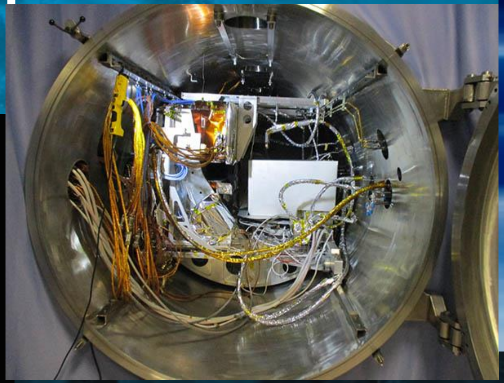
2000

- NOAA-15,16, 17. More microwave channels
- NOAA + EUMETSAT IJPS agreement
- NPOESS/JPSS development
- Collaboration with DoD on the Defense Meteorological Satellite Program and WINDSAT Coriolis
- First hyperspectral infrared sounders



2020

- JPSS series operational
- METOP-SG
- Jason-2/3
- COSMIC-2 GNSS RO
- GOSAT3 / AMSR3
- Next-gen sounder development



2040

- Increased national and international partnerships
- Enterprise ground system
- Capitalize on cutting-edge technology
- Information integration

JPSS Overview

- The Joint Polar Satellite System, or JPSS, is the backbone of global satellite-based observations and products that feed U.S. forecasting models

- The JPSS Program consists of:
  - Five satellites (two in orbit and three in production), each with at least four instruments
  - A multi-mission ground system supporting JPSS and multiple partner satellites

- Right now, our primary focus is on increasing data availability through the launch of our next satellite, JPSS-2, and supporting partner missions

JPSS provides a continuous on-orbit presence from 2011 through 2038

NOAA-20: Today's Prime Operational Satellite

Launched into Low Earth Orbit—512 miles

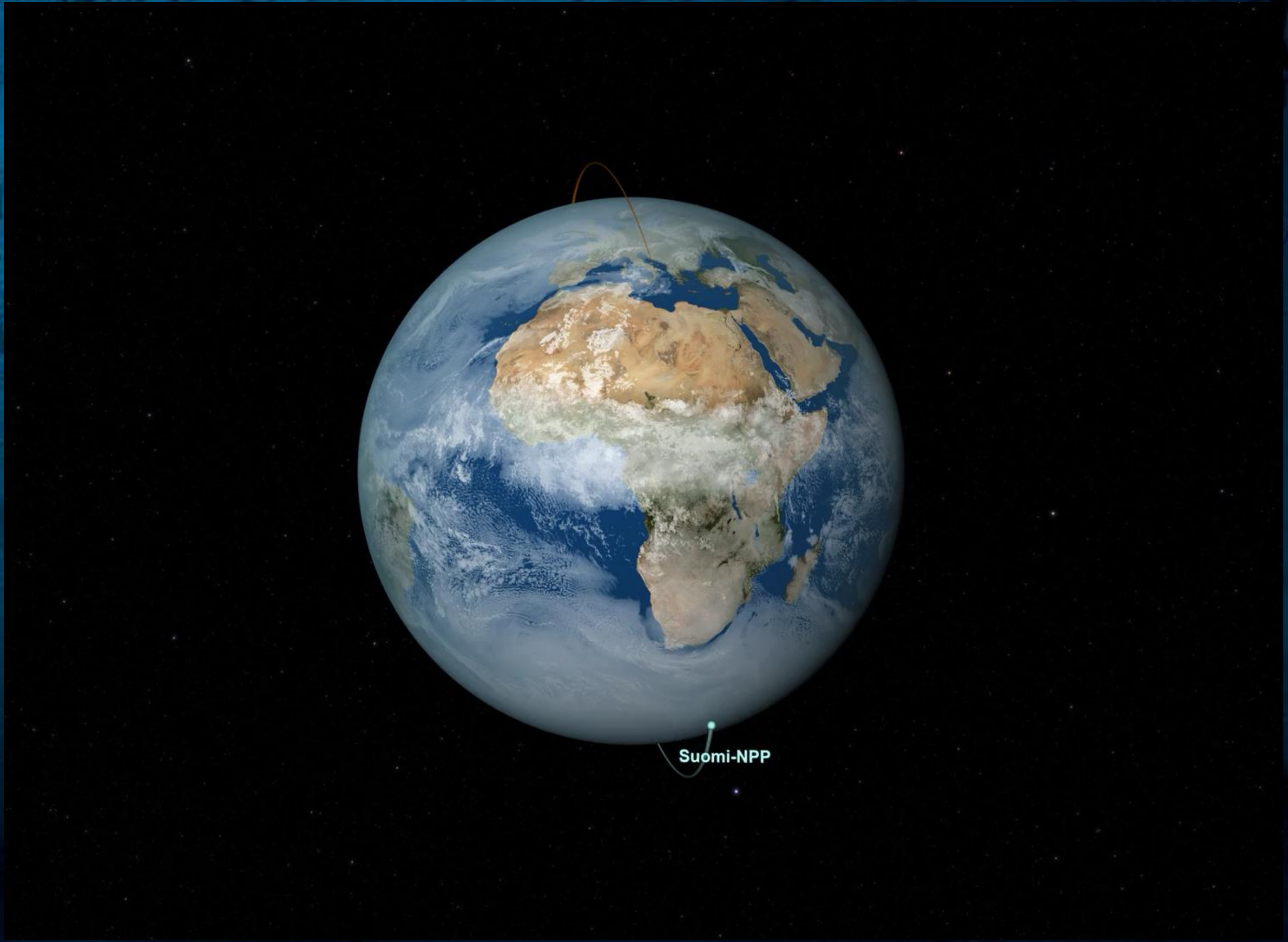
14x Orbits Earth 14 times pole-to-pole with SNPP

2x Images entire globe twice a day

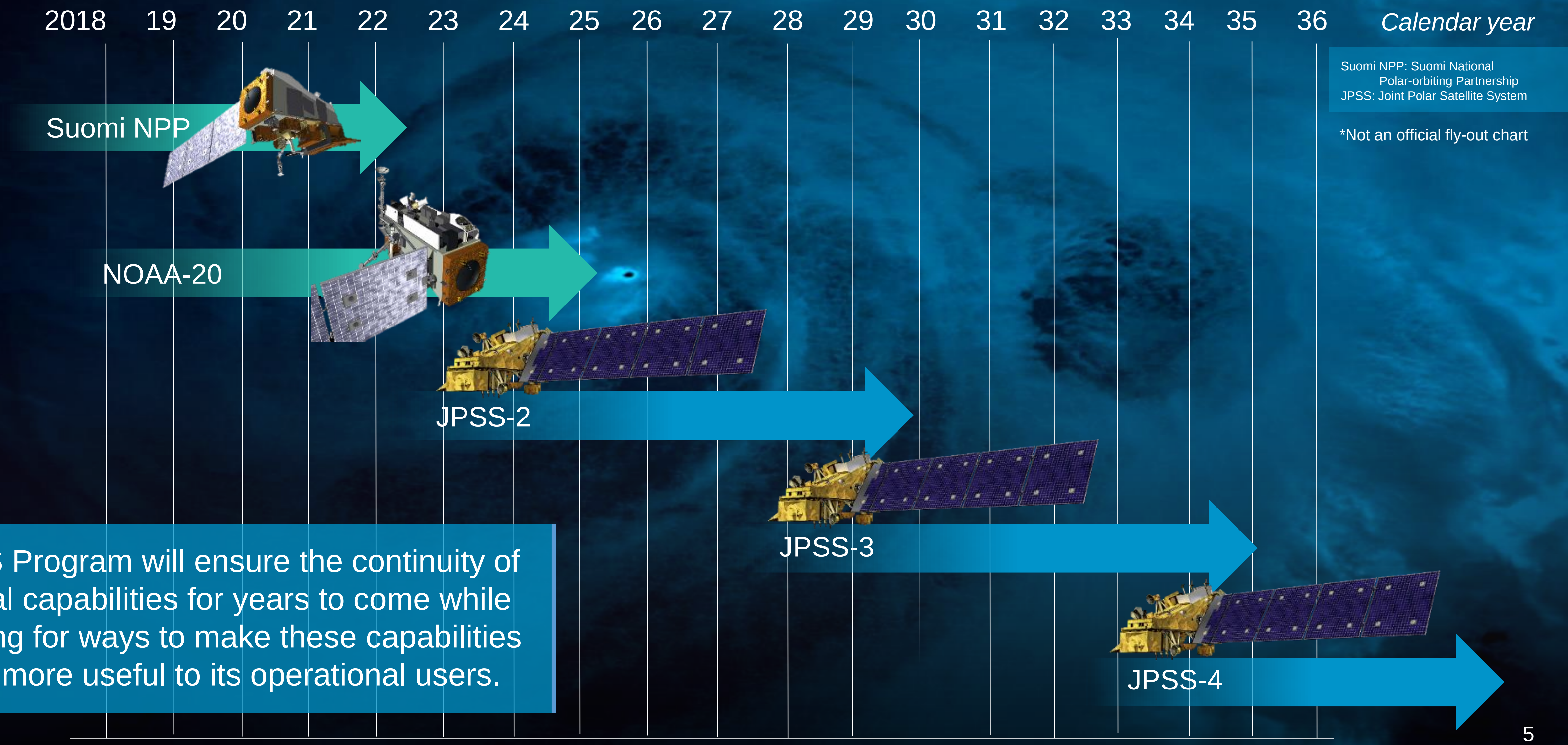
State of the art instrumentation to collect data on Earth's atmosphere, lands, and oceans

Sends more than 2,000 gigabytes of data to Earth every day

NOAA-20 (previously JPSS-1) flies in the same orbit as Suomi NPP, 50 minutes apart



JPSS Continuity of Operations

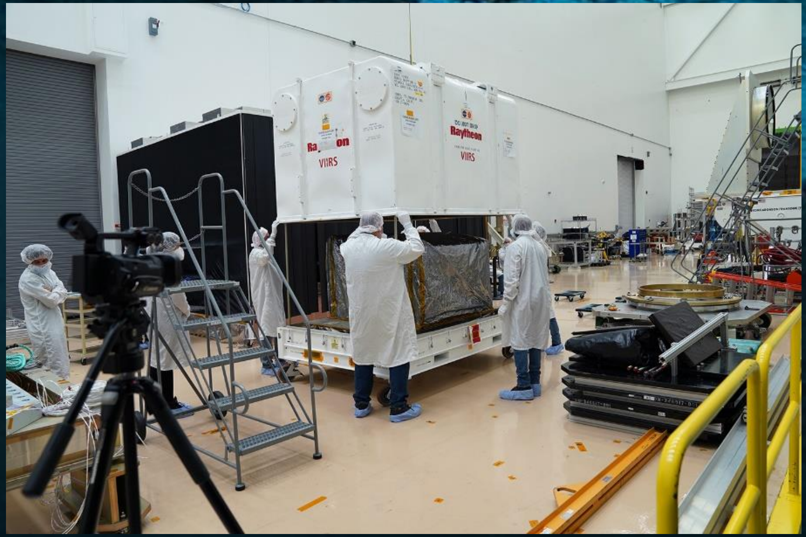


JPSS Program will ensure the continuity of critical capabilities for years to come while looking for ways to make these capabilities even more useful to its operational users.

JPSS-2 Updates

JPSS-2 has made excellent progress towards launch in 2022

- Spacecraft has successfully completed its comprehensive performance test and is starting instrument integration
- All instruments are complete and are starting to be delivered to the spacecraft facility
  - First instrument, VIIRS, has been mated to the spacecraft
  - Second instrument, OMPS, has arrived in Gilbert, AZ
  - CrIS and ATMS will arrive in one month increments
- Satellite (spacecraft plus instruments) environmental testing to begin in spring 2021



Left: The JPSS-2 VIIRS instrument departs the Raytheon facility in mid-September. Credit: Raytheon Intelligence & Space

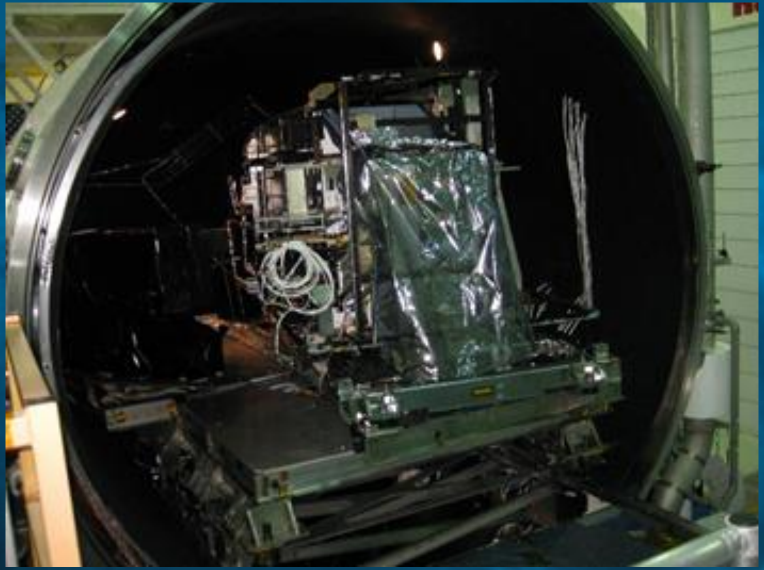
Right: Engineers at Northrop Grumman unpack the VIIRS instrument from its shipping container at the spacecraft facility in Gilbert, AZ. Credit: Northrop Grumman Space Systems

JPSS-3 & 4 Updates

While the JPSS-2 satellite development is underway, progress is also being made towards JPSS-3 & 4 satellites.

JPSS-3 Updates:

Component	Scheduled Completion	Update
CrIS	May 2021	Preparing for electromagnetic interference instrument testing
VIIRS	June 2021	Undergoing instrument thermal vacuum testing
OMPS	November 2021	Preparing for thermal vacuum testing of its nadir sensor
ATMS	February 2022	In final assembly preparing for environmental testing in February 2021
Libera	Spring 2024	Under development
Spacecraft Structure & Harness	April 2022	Assembled



JPSS-3 VIIRS in TVAC Chamber

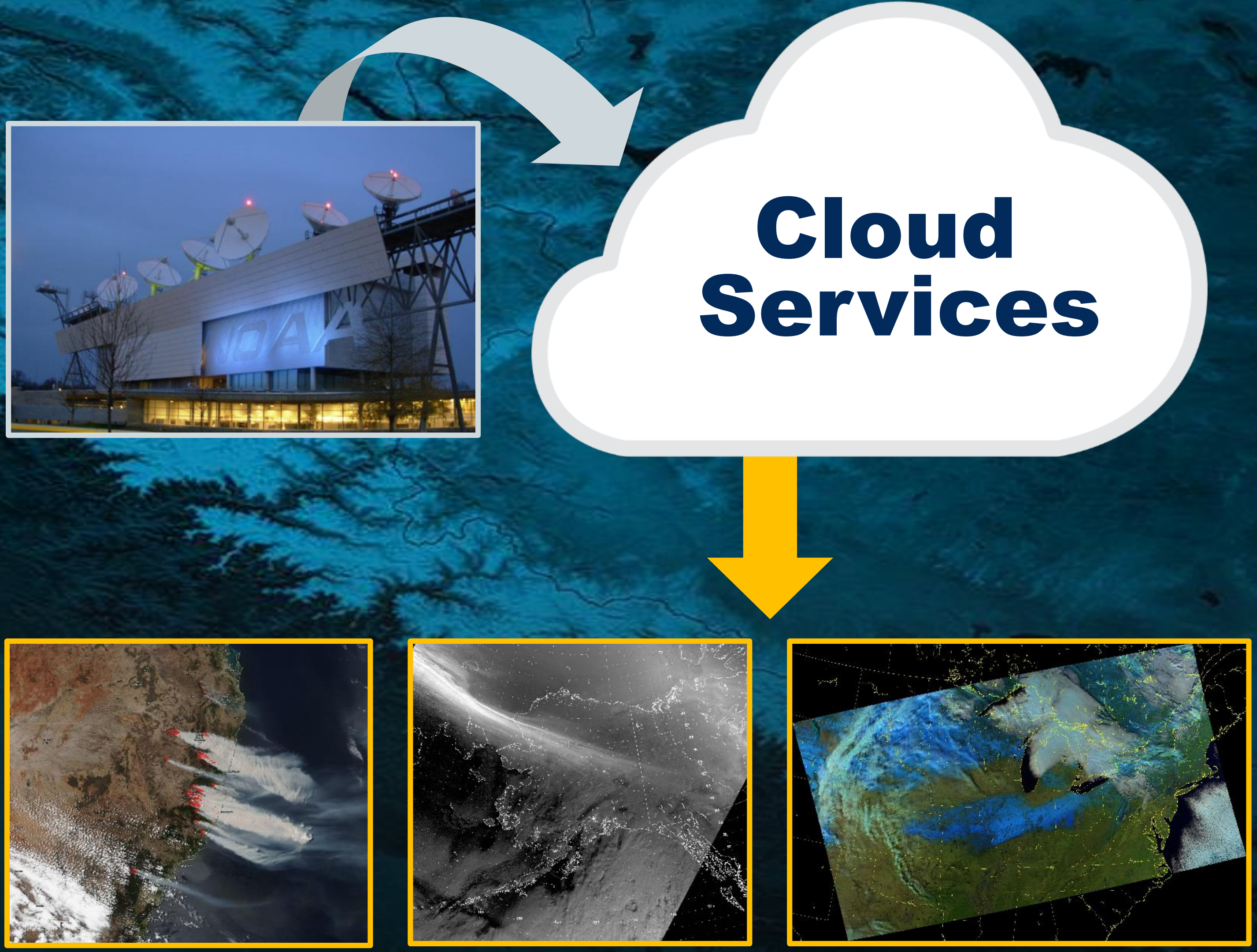
Instruments for JPSS-4 will start delivery in July 2022 with the spacecraft being ready for instrument integration in April 2023.

Enterprise Ground System

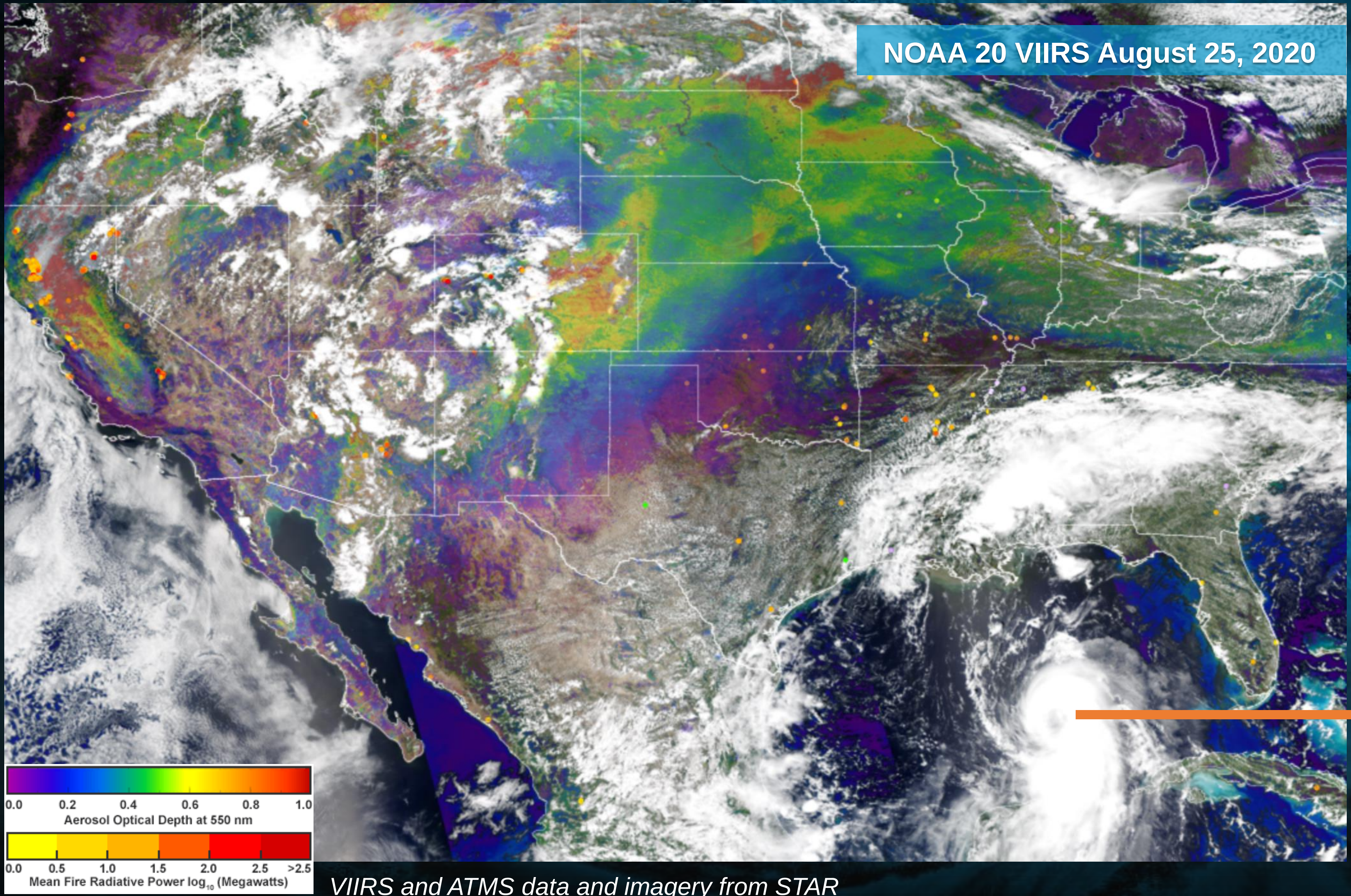
- JPSS has augmented the ground system to provide a suite of services to a heterogenous constellation of NOAA and partner missions including EUMETSAT, JAXA, the U.S. Space Force, and NASA
- JPSS is moving data processing to the Cloud this year
- We are improving JPSS Operational Mission Planning and collaborating with NESDIS partners to expand on the Enterprise Mission Planning Tool
- In the future, the ground system will support new missions, exploit new technologies, improve cybersecurity and increase automation through continuous evolution

Moving Data Processing to the Cloud

- Modernizing technology to accelerate data delivery to end users
- Reducing long-term cost by migrating data from on-premises facilities
- Improving user access
- Level I processes will be fully operational in the cloud in December 2020
- Future Cloud-to-Cloud user access and data delivery in work

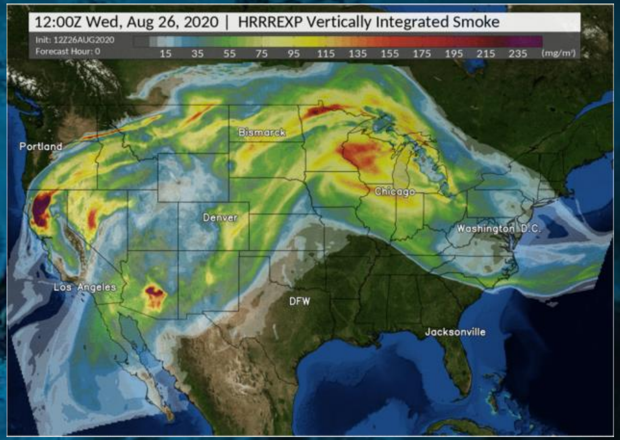


California Fires and Hurricane Laura



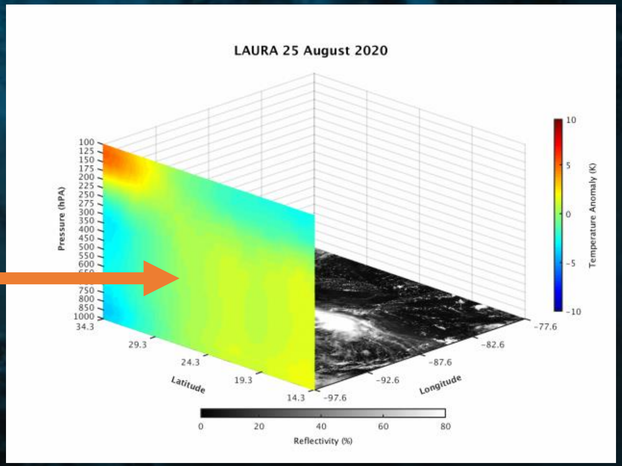
VIIRS and ATMS data and imagery from STAR

HRRR Vertically Integrated Smoke



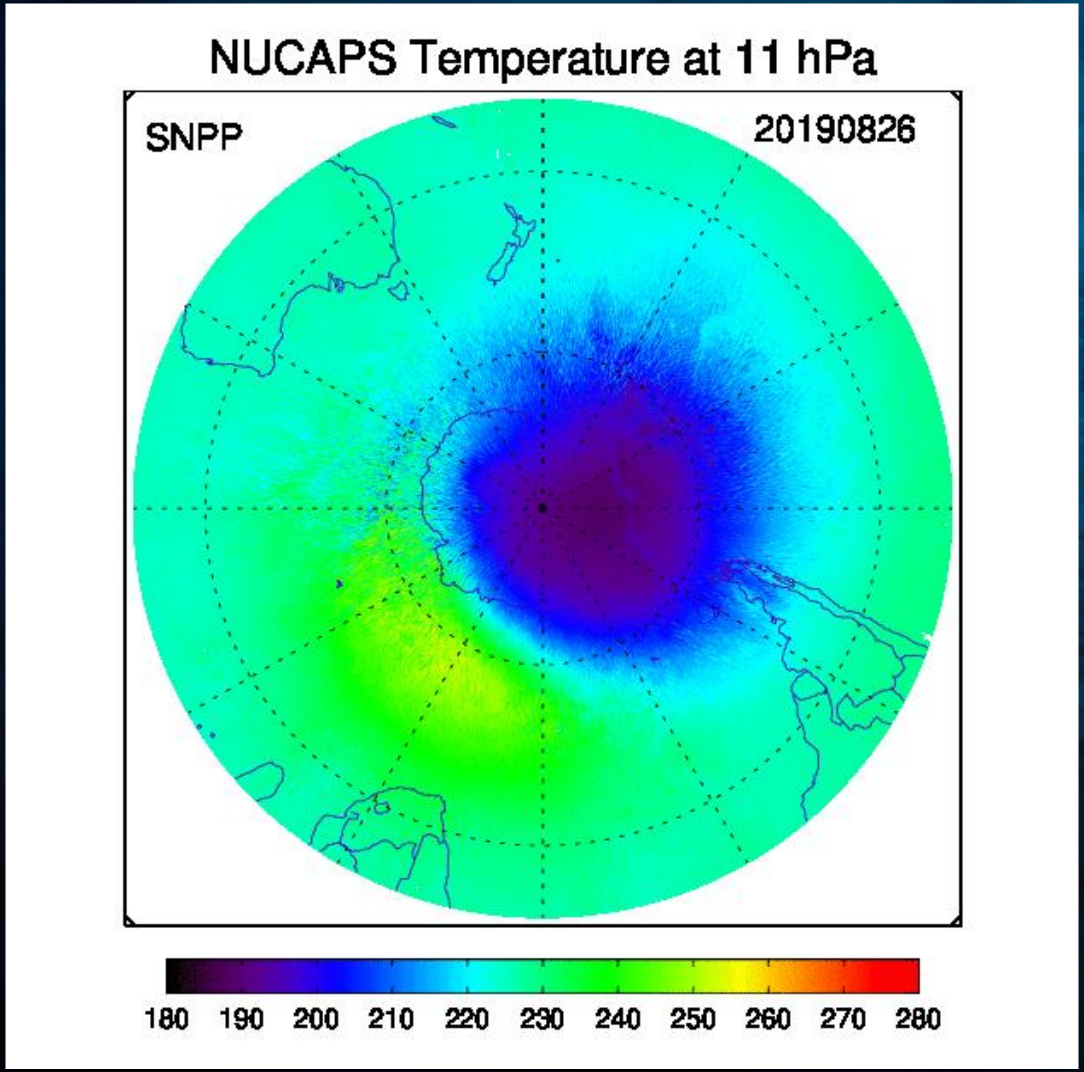
Ravan Ahmadov/CIRES

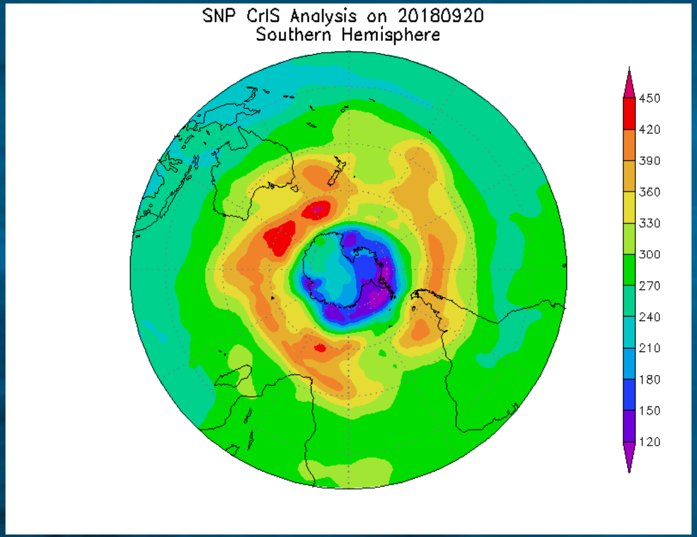
ATMS Hurricane Warm Core Anomaly



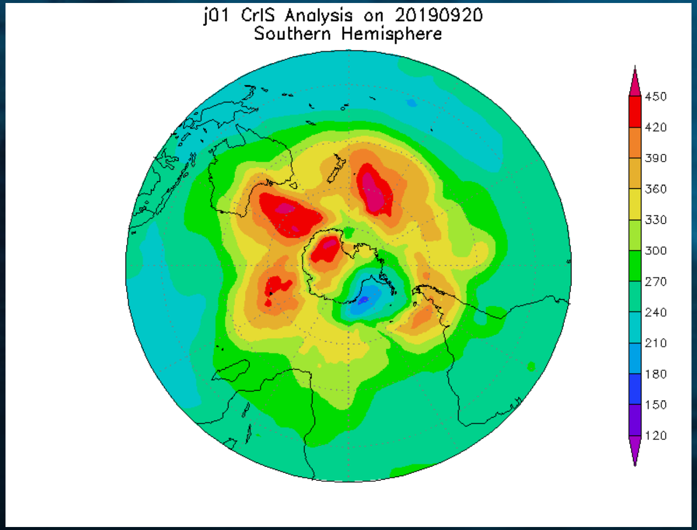
Southern Stratospheric Warming and Ozone Hole (2019)

Stratospheric Temperature



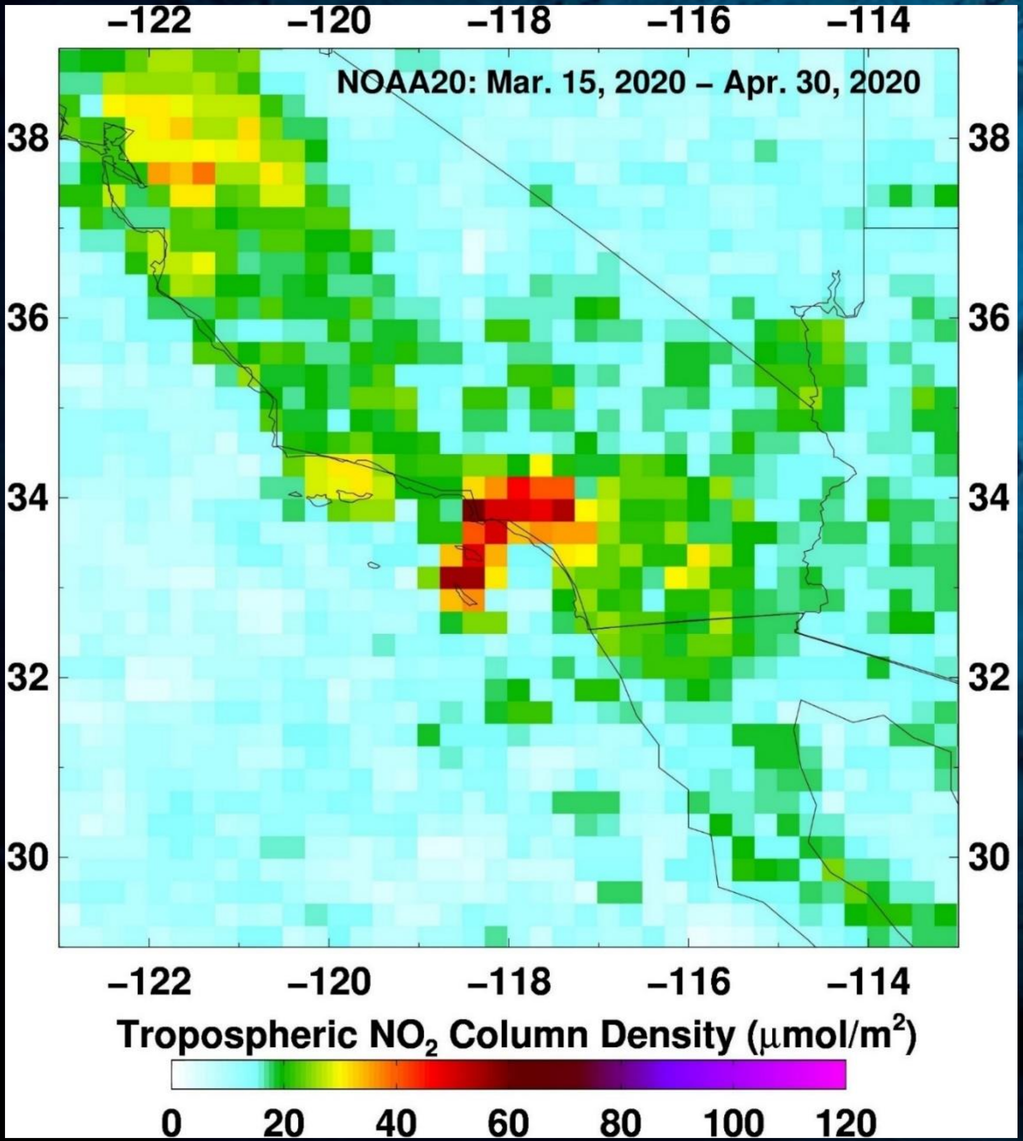


2019

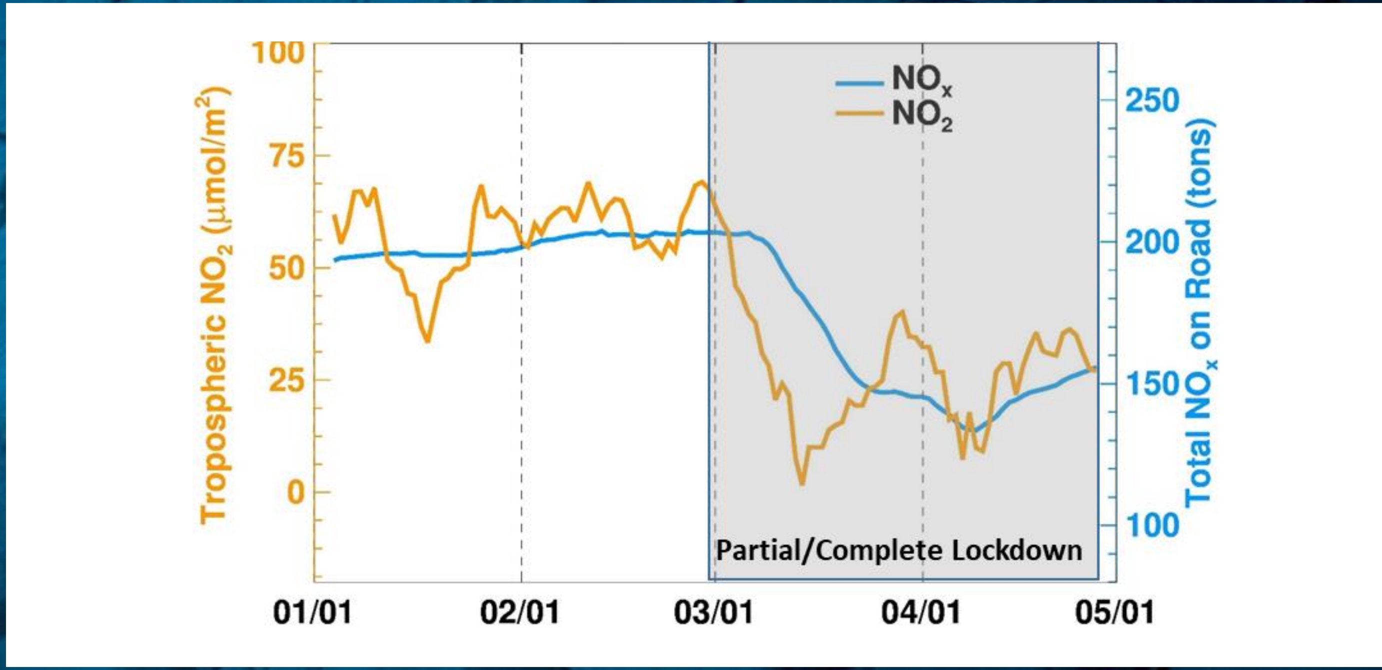


2020

NOAA-20 OMPS NO_2 over California (0.25^o x 0.25^o)

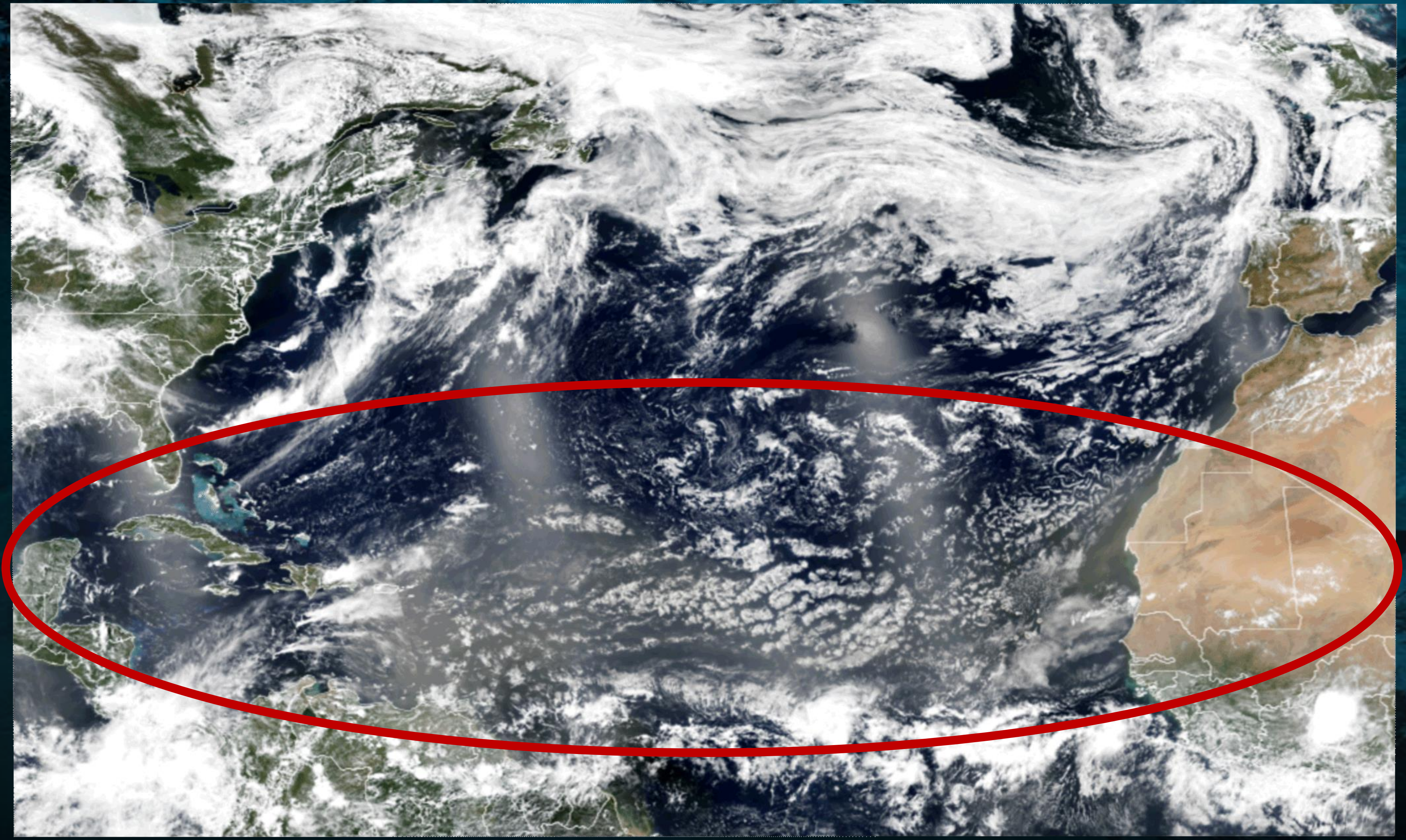


Trends in OMPS NO_2 and On-road NO_x Emissions over LA



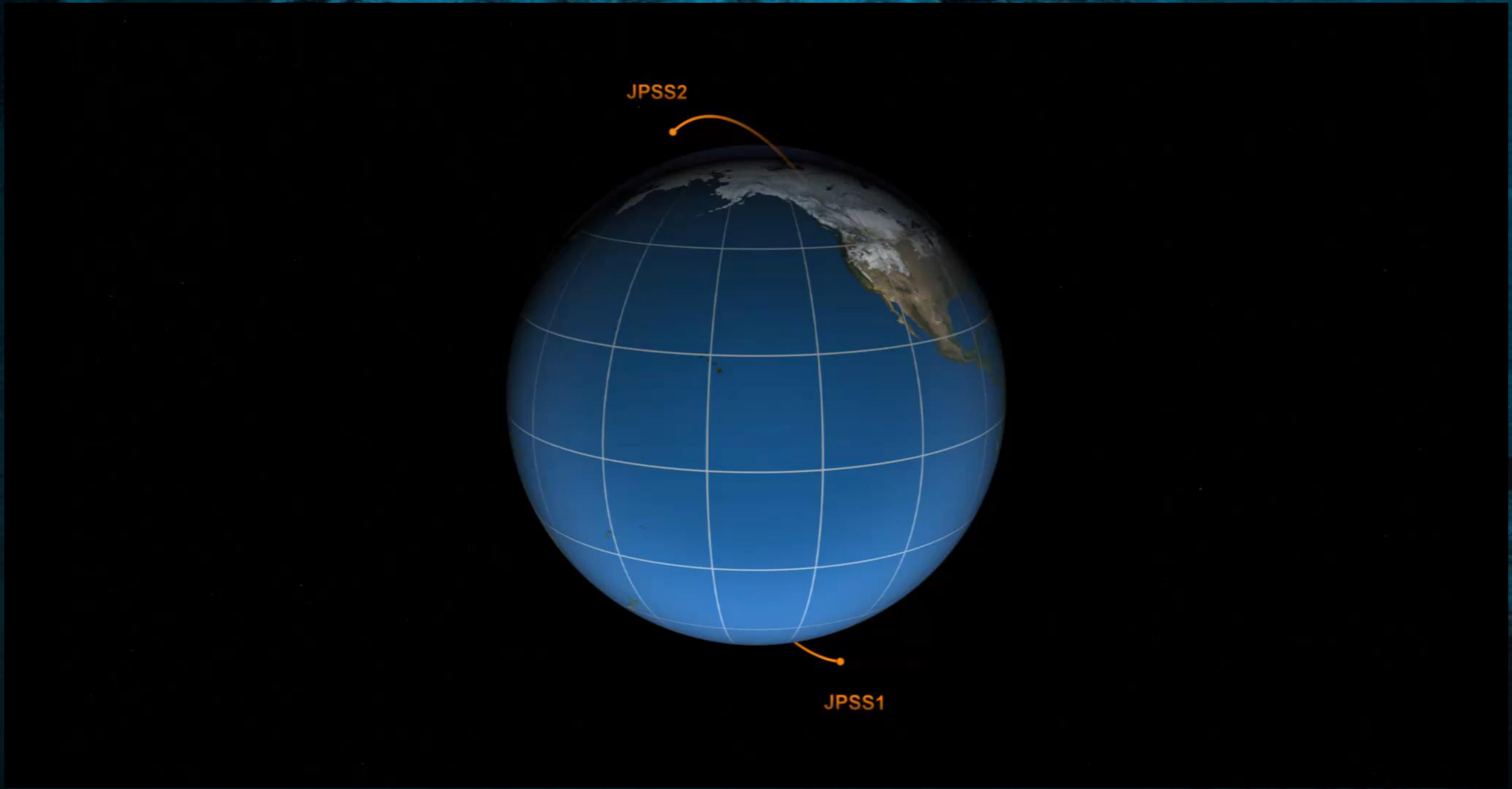
- Due to the COVID-19 pandemic, the U.S. went into a lockdown mid-March 2020
- The lockdown resulted in reduced traffic and NO_x ($NO+NO_2$) emissions from cars and trucks
- Time series of OMPS NO_2 (orange line) and measured on-road traffic emissions (blue curve) both show a drop corresponding to the partial/complete lockdown. *Original NOAA-20 OMPS data are at 17 km x 13 km resolution.*

Saharan Dust Event (June 5–26, 2020)



The Future of LEO

Evolve LEO architecture to enterprise system of systems that exploits and deploys new observational capabilities.



NESDIS Strategic Objectives

NESDIS Reimagined

1 Advance terrestrial observational leadership in geostationary and extended orbits

2 Advance Space Weather observational leadership in LEO, GEO, and extended orbits

3 **Evolve LEO architecture to enterprise system of systems that exploits and deploys new observational capabilities**

Next Gen Sounder Initiative FY2020/21/22

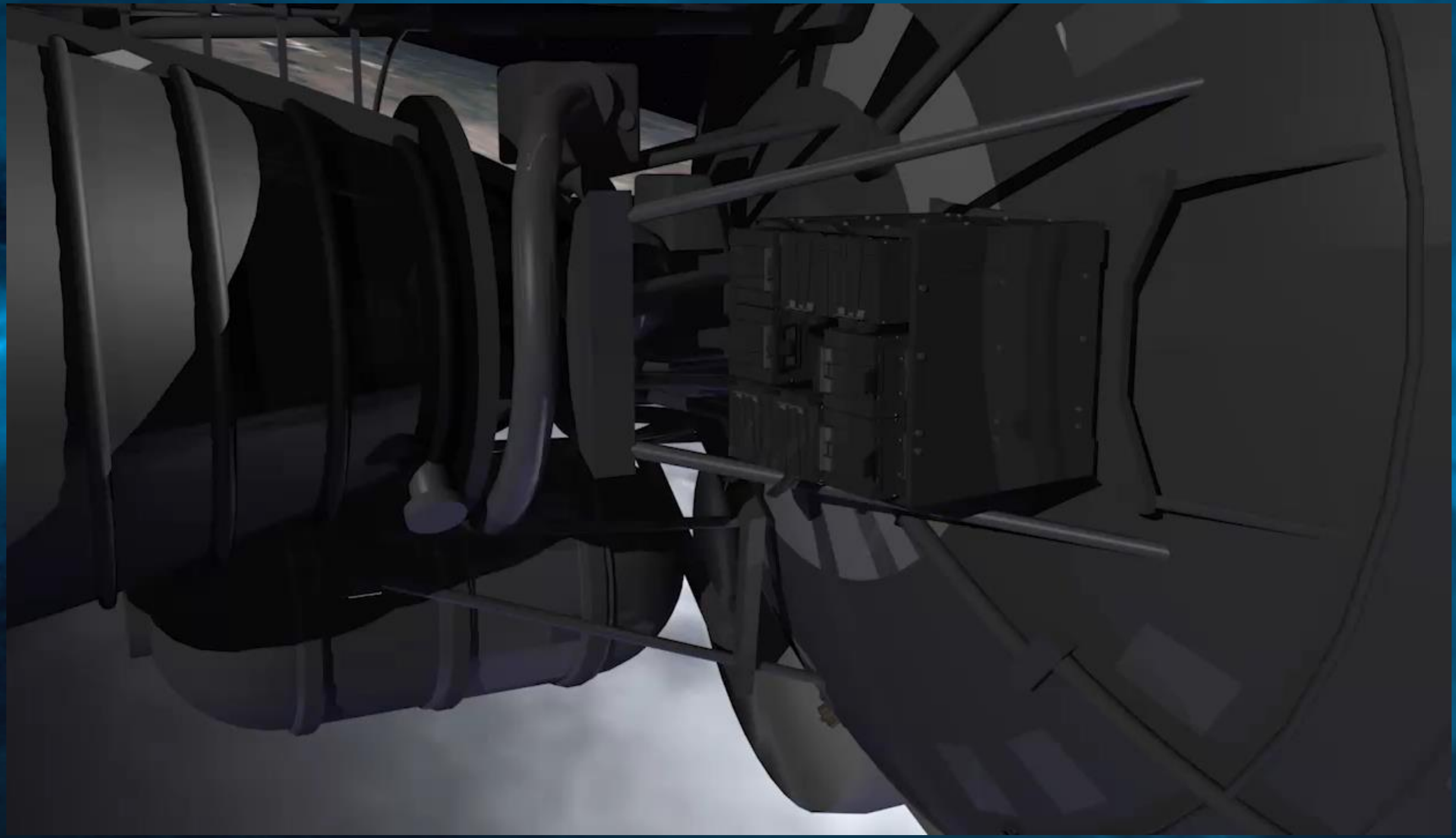
4 Develop agile, scalable ground capability to improve efficiency of service deliverables and ingest of data from all sources

5 Provide consistent ongoing enterprise-wide user engagement to ensure timely response to user needs

6 Deliver integrated program development to provide a suite of products and services

Exploiting the Trends: Leveraging Advancements

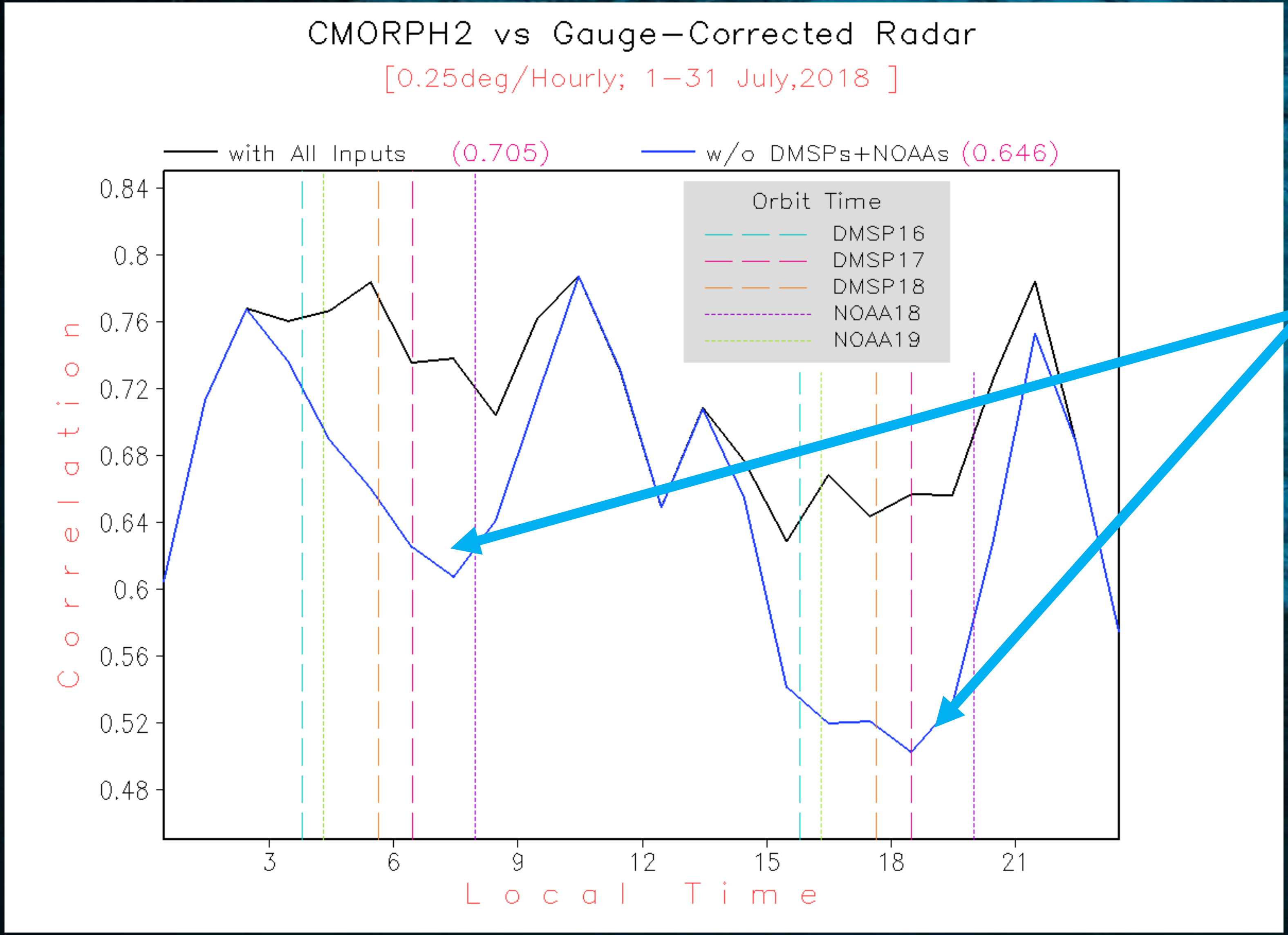
- Make use of industry's significant investment of funding, expertise, and innovation to date.
- Put capabilities where and when we want them, enabled by shorter development timelines and more frequent launches.
- Provide more capability at a better price, leveraging smaller and more capable instruments and satellites.
- Achieve greater agility to incorporate continuous advancement, using new business models and partners.



LEO Sounder Initiative: Background

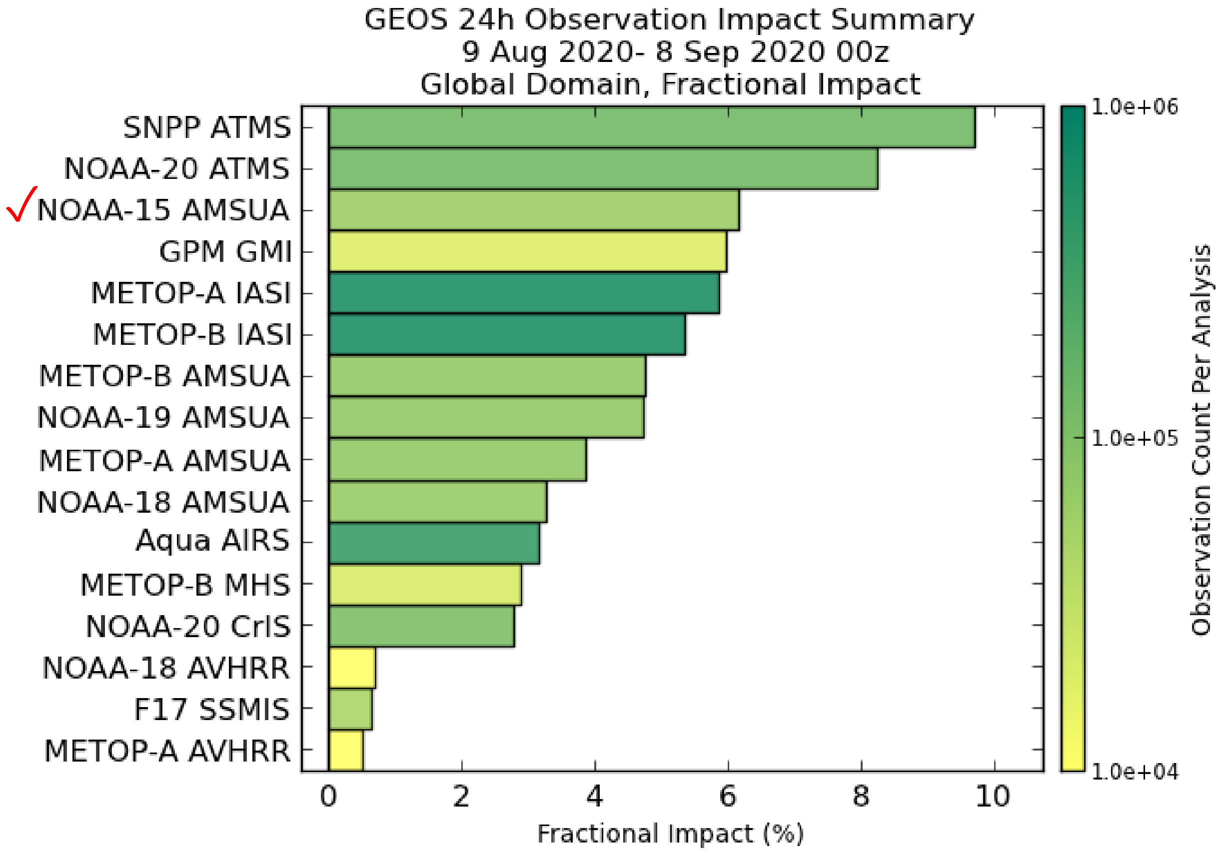
- The NOAA Satellite Observing System Architecture (NSOSA) study recommends a partially-disaggregated LEO architecture
- LEO Sounder Initiative serves as risk reduction and operational pathfinder for the post JPSS-era as Windsat and S-NPP successfully served for the current family of systems.
- Iteratively developing a government reference architecture and associated roadmap for the LEO Sounder Initiative to identify basic elements of cost
- Awarded fifteen LEO Sounder study contracts for instrument, satellite and architecture concepts
- Completed initial Mission Design Lab run to evaluate the viability of a common spacecraft to accommodate combinations of sounder instruments in a variety of orbits

Loss of Early Morning Satellites Results in a Significant Degradation in the Accuracy of Precipitation Products

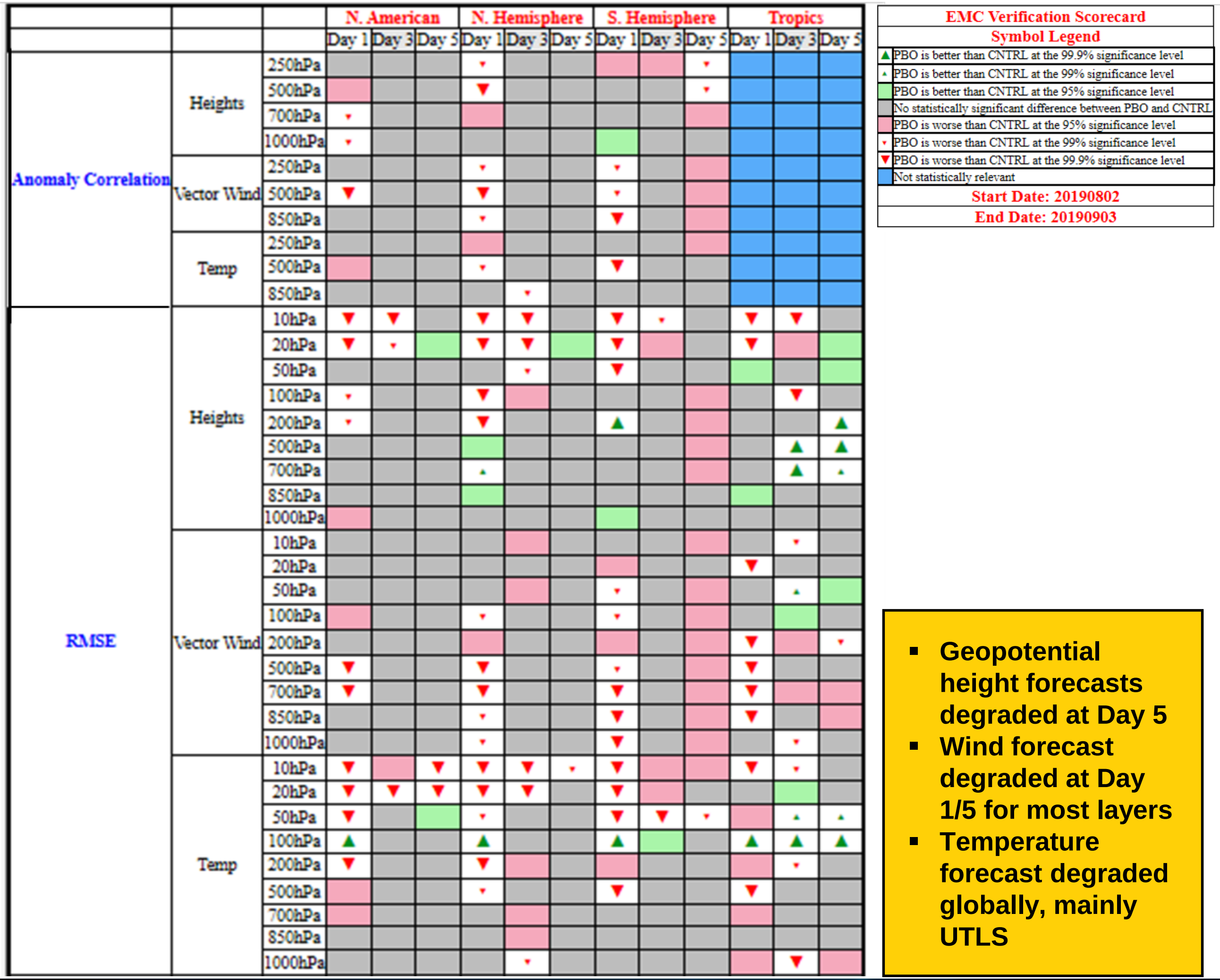


- Removing the older DMSP and NOAA satellites reduces the precipitation accuracy from the black line to the blue line
- This resulting degradation reduces forecasting accuracy and real-time assessment for severe weather (e.g. precipitation and flooding)

Impact of Legacy POES on NWP



Contribution of Legacy POES is significant (especially early morning obs) (NASA/GMAO)



- **Geopotential height forecasts degraded at Day 5**
- **Wind forecast degraded at Day 1/5 for most layers**
- **Temperature forecast degraded globally, mainly UTLS**

Impact of loss of legacy POES and EOS sensors on NWP is statistically significant (NESDIS/STAR)

Near-Term Project Plan for SounderSat

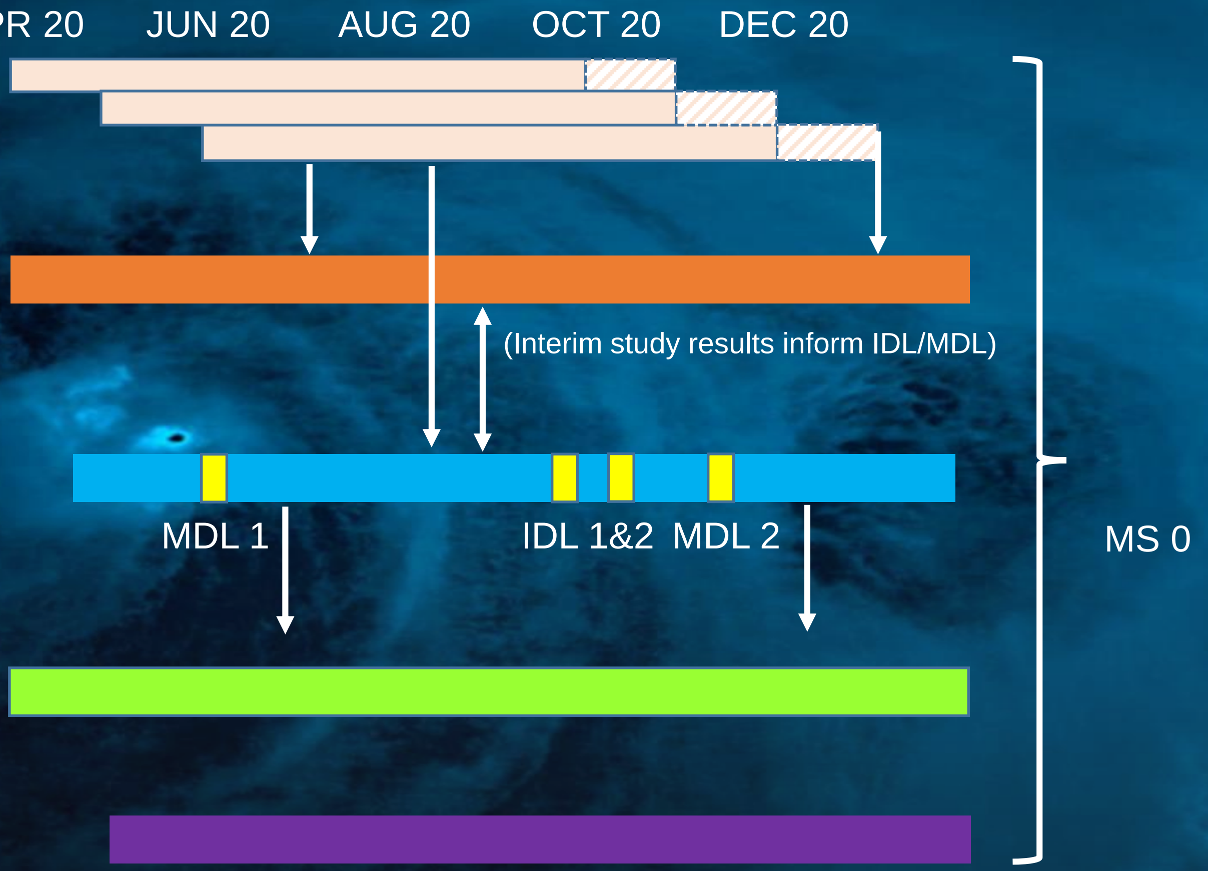
Sounder Studies, RFI Responses, Lessons Learned, Tech Maturation Trends

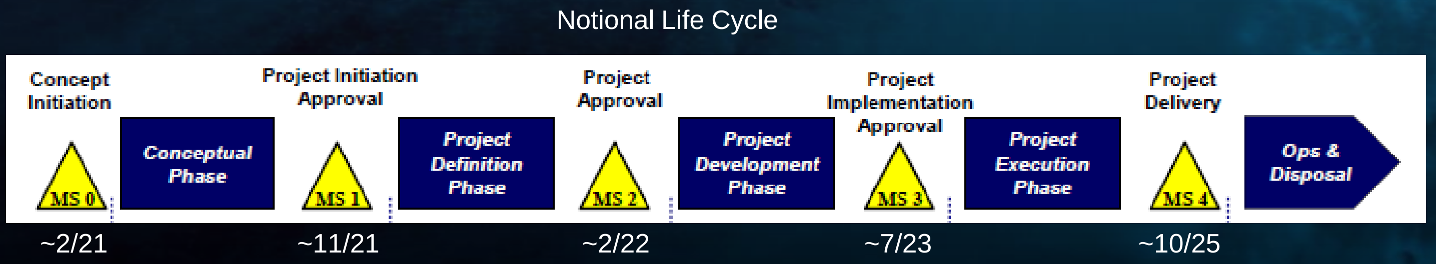
Science Studies
- Disaggregated observations assessment
- Band evaluation and substitution
- NWP data exploitation

Architecture Analysis
- Gov't reference architecture
- In-house concept studies, prototypes and demos
- BOEs

Budget
- Cost Estimation, Modeling & Analysis
- FY2022 PPBE

Programmatic Preps
- Program Plan
- Level 1 Requirements
- ConOps
- Acquisition Planning
- Schedule





What is after SounderSat?

Rank Order (priority for improvement)	Objective	Priority within Group	Swing weight within group	Integrated swing weight
1	D1-Assurance of core capabilities	D1	0.32	0.068538
2	A13-3D winds	A1	0.127	0.066988
4	A9-Global GNSS-RO soundings	A3	0.118	0.063206
5	D2-Compatibility with fixed budgets	D2	0.23	0.060948
6	A2-Global real-time weather imagery	A4	0.111	0.058438
7	A7-Global RT vertical MW soundings	A5	0.101	0.055681
8	A5-Global RT vertical IR soundings	A6	0.09	0.05269
11	A12-Ocean surface vector wind	A7	0.076	0.042643
12	D3-Assurance of all capabilities	D3	0.16	0.039096
13	D4-Programmatic responsiveness and adaptability	D4	0.15	0.035549
14	A3-Non-Real-Time global weather imagery	A8	0.062	0.032066

15	A4-Global ocean color/phytoplankton composition	A9	0.048	0.028707
16	A15-Microwave Imagery	A10	0.036	0.025524
26	D5-Develop and maintain international partnerships	D5	0.08	0.00714
27	D6-Low risk at constellation level	D6	0.06	0.006429
28	A18-Radar-based global precipitation rate	A12	0.02	0.00584
30	A8-Regional (CONUS) RT vertical MW soundings	A13	0.015	0.004956
32	A6-Regional (CONUS) RT vertical IR soundings	A14	0.011	0.004364
34	A11-Sea surface height (global)	A15	0.009	0.003972
36	A19-Global soundings of chemical concentrations	A16	0.008	0.003714
38	A14-Ozone	A17	0.007	0.003545
40	A16-Outgoing LW radiation	A18	0.006	0.003435

Based on NSOSA Study – SPRWG Report, 22 March 2018

THANK YOU!

For more information visit: www.jpss.noaa.gov

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